RECENT DEVELOPMENTS IN VEGETABLE INSECTICIDES

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Background Showing Importance of Research for Arsenical Substitutes:

In order to provide a proper background for a discussion on recent developments in insecticides used for controlling insects on vegetables, it seems desirable to review very briefly some of the important influences which led to an intensification of the investigations on this subject.

During the early stages in the development of control measures for insect pests on vegetables, it appears that except for occasional speculations as to the quantity of a given food product (such as cabbage) that would need to be eaten at one time to constitute a lethal dose, very little fear was expressed in reports or publications over the increasing use of insecticides containing lead, arsenic, fluorine, and other poisonous materials on many edible plant products. In fact one publication went so far as to declare that "Unfortunately considerable prejudice exists against the use of arsenicals on cabbage. This feeling is groundless and should be discouraged." Consequently, the producers of vegetable crops were taught to rely to a great extent on insecticides containing one or more of these chemicals as a means of combating insect attacks. Occasional epidemics of acute illness resembling poisoning directed attention to the food that the sufferers had consumed and to the fact that some of the vegetable products on the market contained alarmingly large quantities of arsenic. This situation, together with rapid advances in the science of toxicology, resulted in widespread publicity and alarm over the prevalent practice of employing substances for insect control which were known to be toxic to man. Much of this publicity and alarm was stimulated by large-scale seizures and condemnations by officials of this Department and by State health officials of cabbage (1931-1932) cauliflower (1931-1932) and celery (1925) which bore excessive quantities of arsenic. These seizures and condemnations led in turn to the publication of many articles and books dealing with the menace to health incurred by the application of insecticides containing arsenic, lead, or fluorine.

Among the many periodicals which have published numerous articles on this subject may be mentioned the following:

1. The "Nation"
2. The "New Republic"
3. The "St. Louis Post-Despatch"
4. The "New Yorker"
5. "Health and Hygiene"
6. "Consumer's Digest".

7. Monthly bulletins and annual buying guides issued by "Consumers' Research" and "Consumers' Union".

Among the books which have discussed the subject are:

1. "100,000,000 Guinea Pigs"
2. "40,000,000 Guinea Pig Children"
3. "How to Spend Money"
4. "Skin Deep"
5. "Partners in Plunder"
6. "American Chamber of Horrors"

The last-named publication, written by a member of the Food and Drug Administration and issued in 1936, gives in one chapter a vivid and accurate account of the history of the war against hazardous residues on vegetables, assigning this problem equal importance with campaigns against notoriously poisonous medicines, drugs, cosmetics, foods, and related materials.

History of the Development of Substitutes for Arsenicals for Use on Vegetable Crops

Although for many years entomologists had tested, from time to time, and in a general way, the insecticidal value of various plant products, and such materials as pyrethrum and hellebore were often recommended for the control of insect pests, the high cost of these materials, and the limited scope of the experiments performed with them prevented their widespread adoption. Prior to 1932 the principal use of any of these plant products against insects attacking vegetables was confined to the use of pyrethrum in combating the celery leaf-tier. In this instance it was found that pyrethrum was specific for the insect involved and that its use avoided the extreme residue hazard incurred by using any of the arsenical or fluorine compounds on celery. These advantages compensated for the relatively high cost of pyrethrum and led to its general adoption by celery growers.

In no instance was the problem regarding the presence of harmful residues on foods more acute or more difficult in contemplation than in the protection of vegetable crops. Among the many complications to be surmounted in the solution of this problem was the fact that research by specialists in human nutrition during recent years had disclosed the value of the vitamins and minerals contained in the green, leafy, outer parts of many vegetables (such as cabbage, lettuce and celery) which had heretofore been discarded almost universally when preparing such vegetables for the table. The discovery of the importance of vitamins in the diet increased the demand for green, leafy vegetables and it soon became evident that practices of insect control which resulted in heavy deposits of harmful residue on the loose edible leaves of vegetables could no longer be tolerated.

The residue problem in truck crop and garden insect investigations was not confined, however, to the use of poisonous substances on leafy vegetables since similar problems were pressing for solution in the instance of the Mexican bean beetle, pepper weevil, vegetable weevil, tomato fruitworm, cabbage maggot on radish and turnips, spinach maggot, melonworm and pickleworm, raspberry fruitworm, strawberry weevil, and hornworms and flea beetles on tobacco.

Workers in the Division of Truck Crop and Garden Insect Investigations had been active for some years in investigating the possibilities of utilizing organic insecticides considered harmless to the consumer. Therefore, when a legal tolerance was established for arsenic on vegetable products placed on the market, and sensational seizures of large quantities of cabbage and cauliflower bearing excessive residues were made during 1931 and 1932, an exhaustive inventory was taken of the organic materials available for insect control. At this time a program of intensive and large-scale experiments was inaugurated with the primary objective of devising methods of insect control that would eliminate the harmful residue hazard.

In furtherance of this objective and as an initial step, investigations performed at field laboratories of this Division located at Baton Rouge, La., and Charleston, S. C., demonstrated conclusively that in order to avoid excessive harmful residue none of the compounds containing arsenic should be used on any part of the cabbage plant that is to be marketed. Paris green, lead arsenate, calcium arsenate, and cryolite were used in these tests. These series of experiments "took the guess-work" out of the arsenical residue question on cabbage and constituted such a distinct and important advance in our knowledge of the residue problem that the conclusions just stated and which were published in Circular 411 (February 1937) have been adopted widely by State workers and incorporated in their published recommendations.

As a part of the residue studies there were made a series of detailed observations of plant growth on such crops as cabbage, celery, spinach and lettuce in order to determine what effect stripping or preparing the product for harvest would have on the removal of residues present on discarded portions. It was found that this type of work yielded exceptionally valuable information on a phase of the residue problem previously not investigated, since the horticulturists had never considered it important to learn just what part of these vegetables were sent to market.

Since the results of the residue experiments on cabbage had shown that the use of insecticides containing harmful materials was practically prohibited for the control of the more common species of caterpillars infesting this crop, studies were initiated in 1932 which had for their objective the finding of materials which would kill these caterpillars and not leave harmful residues. The more intensive studies were performed at Baton Rouge and Charleston and the chart*/ shows briefly the performance of the insecticides tested, arranged according to the order

of their effectiveness against each species of cabbage caterpillar listed.

It will be noted from the chart exhibited*/ that at dilutions of various insecticides which may be considered to be within the range of practical use by the grower, derris dust mixtures which do not leave harmful residues at the dilutions shown, were superior or equal to the arsenical or fluorine compounds, which have been used commonly against the three most important species of caterpillars found on cabbage. (Experiments by other workers of the Division have indicated that cube of the same strength may be used instead of derris.) Similar results were obtained with compounds containing derris or cube against cabbage caterpillars infesting cauliflower in California. For several species of cutworms and for the corn earworm (Agrotinae) which sometimes attack cabbage during the fall season in the South, it was found that none of the organic insecticides were effective and that dependence must be placed upon applications of the arsenical or fluorine compounds before the heads of cabbage begin to form. These results, which demonstrated definitely for the first time the feasibility of controlling the common cabbage caterpillars on cabbage and cauliflower without incurring the harmful residue hazard, have been disseminated widely in a series of E-series circulars, as well as in Farmers' Bulletin 1371, and have been adopted in whole or in part by State workers in making their control recommendations.

The insecticide investigations on cabbage caterpillars were paralleled by similar activities in other work projects of the Division, of which the following were the most important:

1. Sanford, Fla.: A dust mixture consisting of equal parts of pyrethrum and tobacco dust controlled the celery leaf-tier and avoided all chance of harmful residue.

2. Columbus, Ohio, Norfolk, Va., and Grand Junction, Colo.: Sprays or dust mixtures containing derris or cube were found to control the Mexican bean beetle, thus solving all critical questions relating to harmful residue and plant injury from insecticides on this problem. These results were far-reaching in their effect and have been adopted by all workers in entomology as standard procedure. A detailed discussion relating to the development of these insecticides against the Mexican bean beetle and other insects affecting truck and garden crops will be presented by Dr. N. F. Howard.

3. Baton Rouge, La.: Dust mixtures containing derris or cube proved effective in protecting turnip and mustard from injury by the turnip aphid, a widely distributed pest on leafy vegetables and not only solved the problem of avoiding harmful residues on affected crops, but served as the initial step, which was followed by many investigators, in the successful use of insecticides containing rotenone against several species of aphids which had heretofore baffled efforts to control them with insecticides.

4. Phoenix, Ariz.: The problem of controlling the cabbage looper on lettuce in the Salt River Valley of Arizona has been solved, apparently by the use of pyrethrum dust mixtures, under conditions which made the use of organic insecticides imperative.

5. Puyallup, Wash.: Information was obtained that the raspberry fruitworm can be controlled by the use of sprays or dust mixtures containing derris or cube, thus eliminating the use of lead arsenate, formerly recommended, which left residues on the marketed berries if applied before the plants were in bloom.

Specificity of Insecticides Against Some Important Insects Attacking Vegetables

During the progress of experiments to determine the identity and proper dilution of insecticides that would control certain of the insects attacking vegetables and not leave harmful residues it became apparent that some of these insecticides were characterized by distinctly specific responses, as disclosed by tests in the laboratory and in the field.

For example, it was found (as shown by the chart exhibited*/) that pyrethrum is very effective against the celery leaf-tier whereas derris is noneffective and lead arsenate and cryolite are not sufficiently effective, against the half-grown or nearly full-grown stages, at the dilutions ordinarily considered practicable, to warrant the risk of residue hazard incurred by their use. These experiments demonstrated conclusively for the first time that money spent by the celery growers for derris, cryolite or lead arsenate to combat the celery leaf tier was very largely wasted and that all their efforts and funds should be expended on pyrethrum to control this pest.

On the other hand (as illustrated partly by the chart exhibited*/) comparable tests with these four insecticides showed that derris or pyrethrum were highly specific against all stages of the imported cabbage worm and much more effective (especially with the half-grown or larger stages) than either lead arsenate or cryolite. These results emphasized that the organic insecticides (preferably derris against large larvae) could be used in controlling this important pest of cole crops without danger of harmful residue and that the other materials were not as suitable.

In experiments against the southern armyworm it was found, however, that in the quarter-grown or larger stages, pyrethrum or derris were very nearly non-toxic and that cryolite or lead arsenate were specific against this widely distributed pest of many vegetable crops in the South. (In this connection note from the chart exhibited*/ that although pyrethrum and derris were apparently quite effective against the newly hatched larvae of the southern armyworm, these materials were not effective against quarter-grown larvae.)

Field tests in various work projects now being prosecuted by the Division of Truck Crop and Garden Insects Investigations, have served to further emphasize the highly specific response of insecticides. For instance, while insecticides containing rotenone have proven effective against some insects (including those mentioned previously in this discussion) such as the Mexican bean beetle, certain species of cabbage worms, pea aphid, turnip aphid, pea weevil, raspberry fruitworm, tobacco flea beetle, red spider and some species of thrips, they have not proven effective against the celery leaf-tier, southern armyworm, tomato fruitworm, tomato pinworm, tomato and tobacco hornworms, zebra caterpillar, mole crickets, pepper weevil, vegetable weevil, sweetpotato weevil, cutworms, and leafhoppers.

*/ NOTE: The charts exhibited at the Division Leaders' Meeting do not accompany this paper.